FOR DISTRICT USE ONLY

SCD Name: ____________________
SCD RFA No: ____________________
Fee Pd: $__________
Check No: __________
Voucher No: __________
Date Complete RFA Recd: __________
RFA Cert. Date: __________
RFA Expiration Date: __________
Chapt. 251 Appl. No: __________

Request for Authorization (RFA) Form

State of New Jersey

Department of Environmental Protection and Energy
Office of Land and Water Planning

In cooperation with

Department of Agriculture, State Soil Conservation Committee
and Soil Conservation Districts

Stormwater Discharge Associated with Construction Activity (NJPDES General Permit No. NJ0088323)

Please complete. Sign, Date, and Notarize on page 3 and submit to the soil conservation district listed on page 4. Please PRINT or TYPE all information clearly.

1. Location of Project or Facility

A. Project Name UOP Superfund Site - Uplands Remediation
B. Location Intersection of State Routes 17 and 120 (Patterson Plank Road)
(Street Address)
C. Municipality East Rutherford D. County Bergen
E. Block No. 105-01 and 104
F. Lot No. 8,2
G State NJ Zip Code 07073 - ______
H Contact Person Mark Kamilow

2. Owner(s) of Project or Facility

A. Name EM Sector Holdings Inc. (Formerly UOP Inc.)
B. Permanent Legal Address Columbia and Park Avenue, P.O. Box 1057R
C. City or Town Morristown
D. State NJ Zip Code 07960 - ______
E. Owner (circle number) 1 city 2 county 3. state 4. federal 5. private 6. religious 7. charitable 8. public school 9. corporate
F. Telephone (201) - 455 - 2119
G. Contact Person Mark Kamilow
H. Parent Company ______ Tele ( ) ___-___
Mailing Address ______
City or Town ______ State ______ Zip Code ______

3. **Agent/Operator / *responsible during term of authorization**

A. Name EM Sector Holdings Inc.

B. Permanent Legal Address 101 Park Avenue

C. City or Town Morristown

D. State NJ Zip Code 07960 - ______

E. Telephone (201) 455-2119 - ______

F. Parent Company ______ Tele ( ) ______-______

Mailing Address ______

City or Town ______ State ______ Zip Code ______

*Agent/Operator has operational control over site specifications and daily activities to assure compliance.

4. **Description of current and proposed land use.**

A. Proposed Use (check the applicable category)

(1) Residential Dwelling

____ Single Family

____ Multi Family

(2) ___Commercial Facility

(3) ___Industrial Facility

(4) ___Mining or Quarrying

(5) ___Public School, Religious, or Charitable Institution

(6) X Other (specify) Land is currently vacant, No future land use has been identified.

B. Area of Disturbance (acres) 15 acres

C. Describe the current land use and general nature of disturbance activity

Current land use: Land is vacant, former industrial facility has been demolished.

General Nature of disturbance activity: excavation/eathwork for remediation project.

D. Stormwater discharge is in what watershed? Berrys Creek

5. **Status of Project or Facility** - land disturbance (circle one)

Existing New Date when construction began or will commence 7 / 11 / 95

No permanent facilities are to be constructed.

6. **Attachments**

A. $200.00 Fee - Payable to "Treasurer - State of New Jersey"

(circle payment type below)

Check or Voucher No.______

B. Arrangements made for publication of newspaper notice. (Circle one) Y N

(see page 4 for sample notice)

For any additional questions please contact the local Soil Conservation District. (see page 4)

5/93

RFA CERTIFICATION
by the Owner and Operator
Construction General Permit

NOTE : A notarized certification by both the Owner and the Agent/Operator is required. If they are the same individual, only one certification is required. Any conveyance or transfer of this project or portion thereof prior to its completion will transfer full responsibility for full compliance to any subsequent owner(s). Transfer of ownership must be filed with the soil conservation district for permit authorization to remain valid.

"I certify under penalty of law that I have personally examined and am familiar with the information submitted in this Request for Authorization and all attached documents, and that this Request for Authorization and all attached documents were prepared by personnel under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete, and that as far as I know, none of the stormwater discharges for which this Request for Authorization is submitted are excluded from authorization by part I.B of NJPDES Permit No. NJ0088323.

"I also certify that I have made arrangements for publication, in a daily or weekly newspaper within the area affected by the facility identified in this RFA, of a notice which states that a request for authorization under general permit No. NJ0088323 to discharge stormwater to surface water(s) has been submitted pursuant to NJAC 7:14A-3.9(b)2. This notice identifies the general permit number, the legal name and address of the owner and operator, the facility name and address, and type of facility or discharges.

Name of Newspaper: Bergen Record, Hackensack, NJ

"I am aware that pursuant to the Water Pollution Control Act, N.J. S. A. 58:10A-1 et seq., there are significant civil and criminal penalties for making a false statement, representation or certification in any application, record, or other document filed or required to be maintained under that Act, including fines and/or imprisonment."

CERTIFICATION BY OWNER OF FACILITY	CERTIFICATION BY AGENT/OPERATOR* RESPONSIBLE FOR FACILITY (during time of RFA Certification)
CORPORATION: (vice president or higher) ______ (signature) ______ (print name) __/__/__ (date)	CORPORATION: (vice president or higher) L R Taunton (signature) TAUNTON (print name) 5/1/95 (date)
PARTNERSHIP OR SOLE PROPRIETORSHIP: (general partner or proprietor) ______ (signature) ______ (print name) __/__/__ (date)	PARTNERSHIP OR SOLE PROPRIETORSHIP: (general partner or proprietor) ______ (signature) ______ (print name) __/__/__ (date)
GOVERNMENT AGENCY OR PUBLIC AGENCY: (principal executive officer or ranking elected official) ______ (signature) ______ (print name) __/__/__ (date)	GOVERNMENT AGENCY OR PUBLIC AGENCY: (principal executive officer or ranking elected ______ (signature) ______ (print name) __/__/__ (date)
NOTARY Sworn before me this ______ day of ______ 19__ ______ (Notary Public)	**NOTARY** Sworn before me this 1ST day of MAY 1995 Sandra L. Pappas (Notary Public)

*Agent/Operator has operational control over site specifications and daily activities to assure compliance. 5/93

SANDRA L. PAPPAS
NOTARY PUBLIC OF NEW JERSEY
My Commission Expires Feb. 14, 2000

New Jersey Soil Conservation Districts

Bergen County	327 Ridgewood Avenue, Paramus, NJ 07652, (201) 261-4407
Burlington County	Tiffany Sq., Suite 100, 2615 Route 38, Mt. Holly, NJ 08060, (609) 267-7410 or 0811
Camden County	403 Commerce Lane, Suite 1, Berlin, NJ 08009 (609) 767-6299 or 3977
Cape-Atlantic	Atlantic County Office Bldg,6260 Old Harding Highway, Mays Landing, NJ 08330, (609) 625-3144
Cumberland County	P.O. Box 144, Route 77, Deerfield, NJ 08313, (609) 451-2422
Freehold:	211 Freehold Road, Manalapan, NJ 07726, (908) 446-2300 (Middlesex and Monmouth Counties)
Gloucester County:	Kandle Center,72 East Holly Avenue, Pitman, NJ, 08071, (609) 589-5250
Hudson, Essex, Passaic	571 Bloomfield Avenue, Verona, NJ 07044 (201) 239-1886
Hunterdon County	Community Services Annex, 8 Gauntt Place, Flemington, NJ 08822 (908) 782-3915 or 788-1397
Mercer County	508 Hughes Drive, Hamilton Square, NJ 08690, (609) 586-9603
Morris County	Morris County Courthouse, P.O. Box 900, Morristown, NJ 07963 (201) 285-2953 or (201) 538-1552
Ocean County	714 Lacey Road, Forked River, NJ 08731, (609) 971-7002
Salem County	1000 East, Route 40, Box 307, Woodstown, NJ 08098, (609) 769-1124
Somerset-Union	Somerset County 4-H Center, 308 Milltown Road, Bridgewater, NJ 08807 (908) 526-2701 or 725-3848
Sussex County	330 Route 206 South, Newton, NJ 07860, (201) 579-5074
Warren County	224 Stiger Street, Hackettstown, NJ, 07840, (908) 852-2579

State Soil Conservation Committee
New Jesey Department of Agriculture
CN 330 Trenton, N J. 08625 (609) 292-5540

SAMPLE PUBLIC NOTICE

A sample Public Notice is provided

Take notice that pursuant to N.J.A.C. 7:14A-3.9(b)2, the XYZ Corporation, 100 First Street, Homeville, N 99999, has submitted a Request for Authorization under General Permit No. NJ0088323 to dischar stormwater from construction activity (or mining activity) at 200 Second Street, Anyplace Townshi Anywhere County, NJ into surface waters of the State.

New Jersey Natural Resources Conservation Program

For District Use Only
Application Number

APPLICATION FOR SOIL EROSION AND SEDIMENT CONTROL PLAN CERTIFICATION

The enclosed soil erosion and sediment control plan and supporting information are submitted for certification pursuant to the Soil Erosion and Sediment Control Act, Chapter 251, P.L. 1975 as amended (NJSA 4:24-39 et seq.). An application for certification of a soil erosion and sediment control plan shall include the items listed on the reverse side of this form.

Name of Project		Project Location: Municipality	
UOP Superfund Site/Uplands Remediation		East Rutherford, Bergen County, NJ	
Project Street Address		Block	Lot
Intersection of State Routes 17 and 120 (Patterson Pland Rd.) East Rutherford, NJ 07073		105.01 and 104	8 and 2
Project Owner(s) Name			Phone
EM Sector Holdings Inc. (formerly UOP Inc.)			(201) 455-2119
Project Owner(s) Address		City	State / Zip
Columbia and Park Avenue, P.O. Box 1057R		Morristown	NJ 07960
Total Area of Project	Total Area of Land to be Disturbed	No. Dwelling or other Units	Fee
41 acres	15 acres	0	$ $1,150.00

Plans Prepared by*			
ENSR Consulting & Engineering - Michael Worthy, P.E.			
Address	State	Zip	Phone
35 Nagog Park Acton	MA	01720	(508) 635-9500

*(Engineering related items of the Soil Erosion and Sediment Control Plan MUST be prepared by or under the direction of and be sealed by a Professional Engineer or Architect licensed in the State of New Jersey, in accordance with NJAC 13:27-6.1 et. seq.)

Agent Responsible During Construction			Job Supervisor		
EM Sector Holdings, Inc.			EM Sector Holdings, Inc.		
Address			Address		
101 Columbia Ave., P.O. Box 1057R, Morristown			101 Columbia Avd., P.O. Box 1057R, Morristown		
State	Zip	Phone	State	Zip	Phone
NJ	07960	(201) 455-2119	NJ	07960	(201) 455-2119

The applicant hereby certifies that all soil erosion and sediment control measures are designed in accordance with current Standards for Soil Erosion and Sediment Control in New Jersey and will be installed in accordance with those Standards and the plan as approved by the Soil Conservation District and agrees as follows:

1. To notify the District in writing at least 48 hours in advance of any land disturbance activity. Failure to provide such notification may result in additional inspection fees.
2. To notify the District upon completion of the Project. (Note: No certificate of occupany can be granted until a report of compliance is issued by the District.
3. To maintain a copy of the certified plan on the project site during construction.
4. To allow District agents to go upon project lands for inspection.
5. That any conveyance of this project or portion thereof prior to its completion will transfer full responsibility for compliance with the certified plan to any subsequent owners.
6. To comply with all terms and conditions of this application and certified plan including payment of all fees prescribed by the district fee schedule hereby incorporated by reference.

The applicant hereby acknowledges that structural measures contained in the Soil Erosion and Sediment Control Plan are reviewed for adequacy to reduce offsite soil erosion and sedimentation and not for adequacy of structural design. The applicant shall retain full responsibility for any damages which may result from any construction activity notwithstanding district certification of the subject soil erosion and sediment control plan. It is understood that approval of the plan submitted with this application shall be valid only for the duration of the initial project approval granted by the municipality. All municipal renewals of this project will require resubmission and approval by the district. In no case shall this approval extend beyond three and one half years at which time resubmission and certification by the district will be required.

1. Applicant Certification†

Signature [signature] Date 5-1-95

Mark Kamilow
Applicant Name (Print)

2. Receipt of fee, plan and supporting documents is hereby acknowledged:

Signature of District Official Date

3. Plan determined complete:

Signature of District Official Date

4. Plan certified, denied or other action as noted above.
Special Remarks:

Signature of District Official Date

† If other than project owner, written authorization of owner must be attached.

SSCC 251 AP9 2/92

An application for certification of a soil erosion and sediment control plan shall include the following items.

1. One copy of the complete subdivision, site plan or construction permit application, including key map as submitted to the municipality (Architectural drawings and building plans and specifications not required.) which includes the following:

   a. Location of present and proposed drains and culverts with their discharge capacities and velocities and supporting computations and identification of conditions below outlets.

   b. Delineation of any area subject to flooding from the 100-year storm in compliance with the Flood Plains Act (NJSA 58:16A) or applicable municipal zoning.

   c. Delineation of streams, wetlands, pursuant to NJSA 13:9B and other significant natural features within the project area.

   ms d. Soils and other natural resource information used. (Delineation of the project site on soil map is desirable.)

   e. Land cover and use of area adjacent to the land disturbance.

   f. All hydraulic and hydrologic data, specifically HEC1, HEC2, WSP2 and TR20 electronic input files, is used, of existing and proposed conditions and a completed copy of the Hydraulic and Hydrologic Data Base Summary Form, SSCC 251 HDF 1.

2. Four* copies of the soil erosion and sediment control plan at the same scale* as the site plan submitted to the municipality or other land use approval agency to include the following (this information shall be detailed on the plat):

   a. Proposed sequence of development including duration of each phase in the sequence.

   b. Site grading plan showing delineation of land areas to be disturbed including proposed cut and fill areas together with existing and proposed profiles of these.

   c. Contours at a two* foot interval, showing present and proposed ground elevation.

   d. Locations of all streams and existing and proposed drains and culverts.

   e. Stability analysis of all channels below all points of stormwater discharge which demonstrates a stable condition will exist or there will be no degradation of the existing stability.

   f. Location and detail of all proposed erosion and sediment control structures including profiles, cross sections, appropriate notes, and supporting computations.

   g. Location and detail of all proposed nonstructural methods of soil stabilization including types and rates of lime, fertilizer, seed, and mulch to be applied.

   h. Control measures for non-growing season stabilization of exposed areas where the establishment of vegetation is planned as the final control measure.

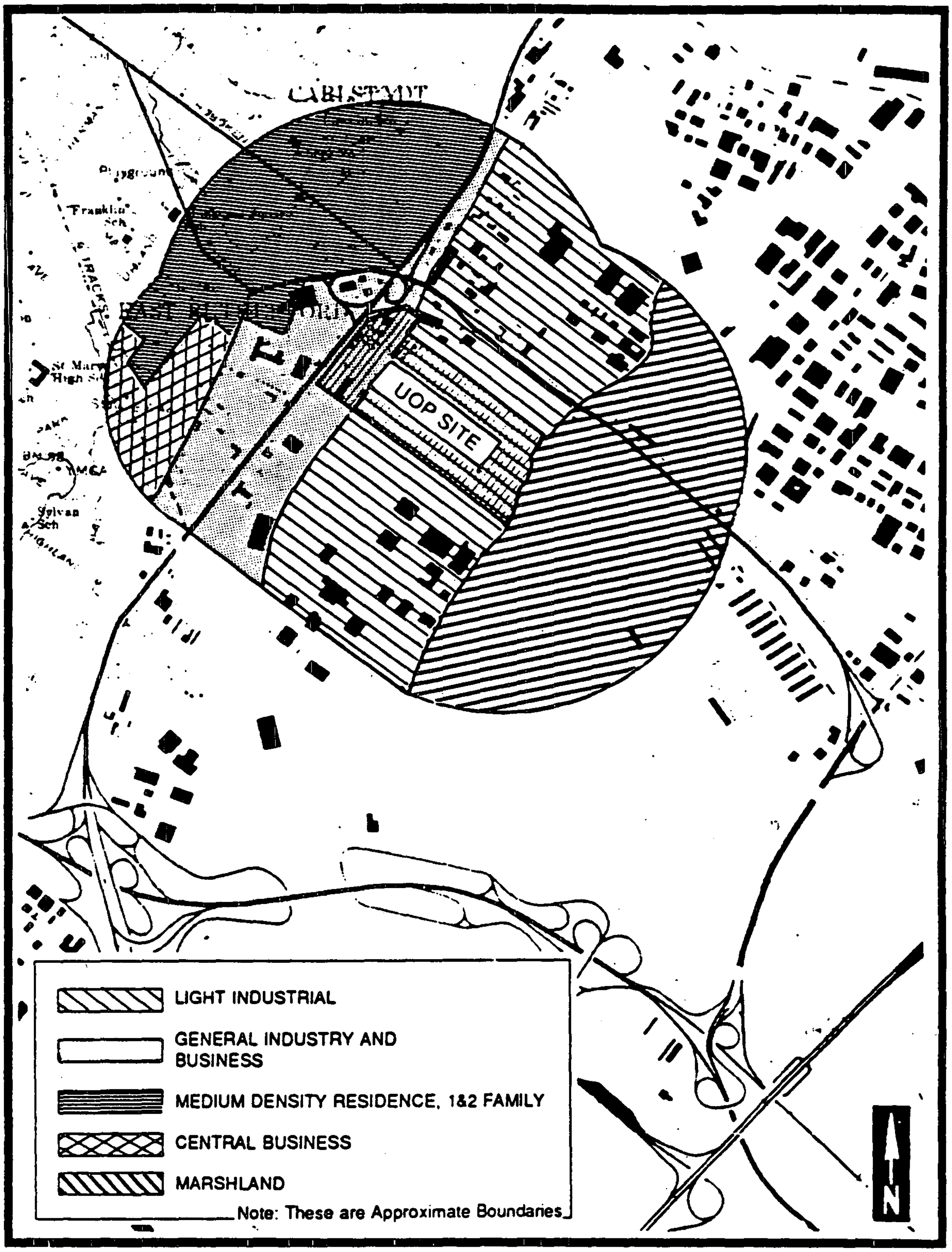
   i. For residential development - control measures to apply to dwelling construction on individual lots and notation that such control measures shall apply to subsequent owners if title is conveyed. This notation shall be shown on the final plat. not applicable

   j. Plans for maintenance of permanent soil erosion and sediment control measures and facilities during and after construction, also indicating who shall have responsibility for such maintenance.

3. Appropriate fees: (As adopted by the individual district.)

4. Additional items as may be required.

*(Individual districts may require modifications in the above list.)

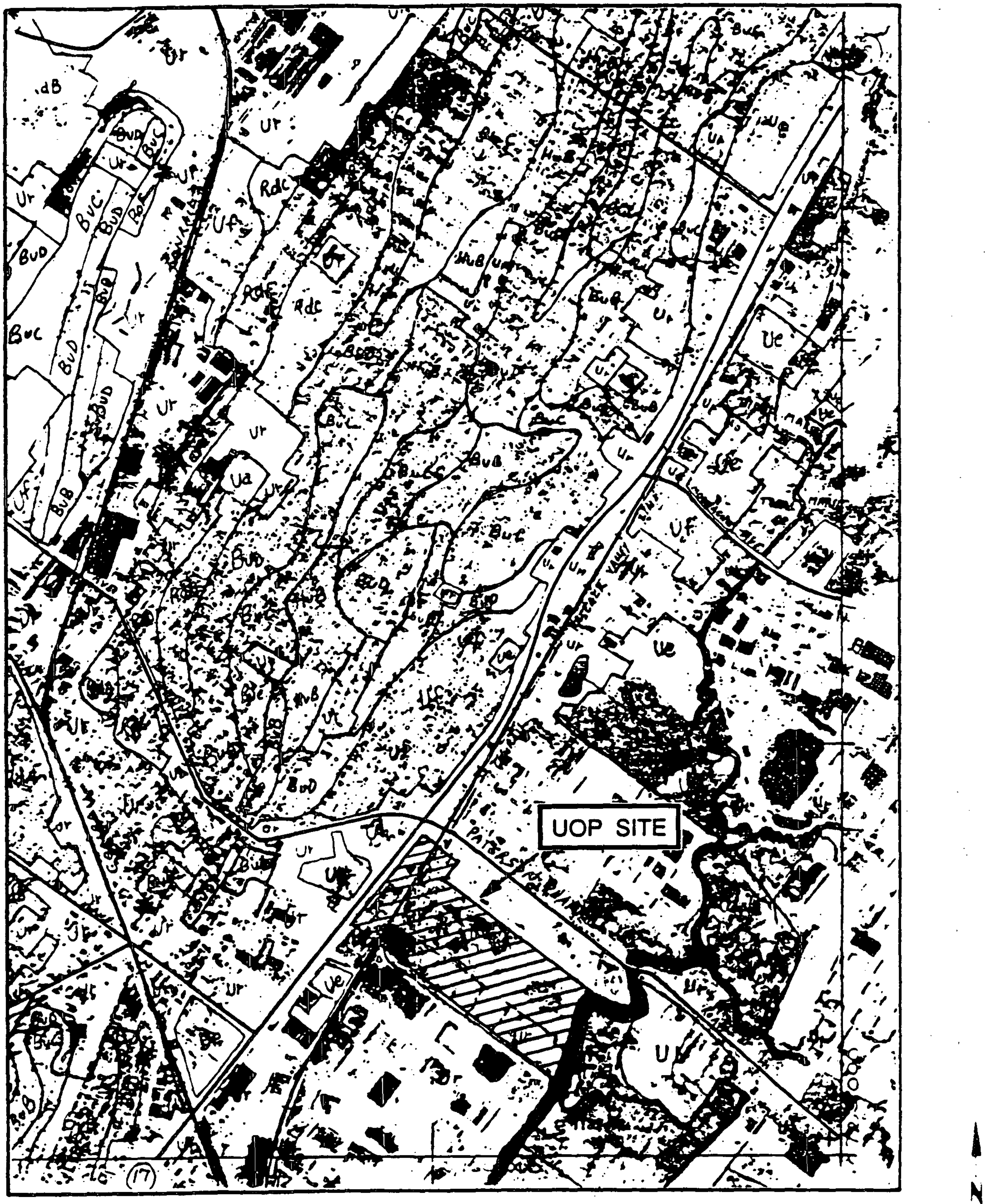


SOURCE: ① - Nierstedt, 1987
② - Comprehensive Zoning Ordinanace of the Borough of E. Rutherford, 1979

0 .5 1 Mile

FIGURE 2-3

Zoned Land Uses Within 1/2 Mile of UOP Site



APPROXIMATE SCALE: 1" = 1667'

FIGURE 2-2

Location of UOP Inc. Site on SCS Soil Survey Sheet

TABLE 1-1

Summary of TR-55 Results
Drainage Areas 1 and 2

Point	Cum Area (acre)	Sheet Flow L (ft)	Sheet Flow T (hr)	Shallow Flow L (ft)	Shallow Flow T (hr)	Time of conc. Tc (hr)	25 yr Peak Q (cfs)
A	0.459	170	0.241	160	0.039	0.28	0.96
B	0.865	170	0.241	340	0.083	0.32	1.72
C	1.974	170	0.241	610	0.149	0.39	3.64
D	2.846	170	0.241	900	0.219	0.46	4.93
E	3.016	170	0.241	1020	0.248	0.49	5.09
Z	0.980	170	0.241	420	0.102	0.34	1.90

TABLE 1-2

Swale Design Summary
Drainage Areas 1 and 2
UOP Site Closure

Swale	Length (ft)	Slope	Cumm Q (cfs)	Bottom Width (ft)	Swale Height (ft)	Depth of Flow (ft)	Velocity (fps)	Type
S-A	160	0.005	0.96	1	0.7	0.4	1.0	Grass
A-B	180	0.005	1.72	1	0.9	0.6	1.2	Grass
B-C	270	0.005	3.64	1	1.1	0.8	1.4	Grass
C-D	290	0.005	4.93	1	1.2	0.9	1.5	Grass
D-E	120	0.005	5.09	1	1.2	0.9	1.5	Grass
S-Z	420	0.005	1.90	1	0.9	0.6	1.2	Grass

UOP SITE CLOSURE
SHEET FLOW ANALYSES AT POINTS U, V, W, AND X

OBJECTIVE: Determine the travel time (Tt) in order to calculate flow velocities (V) at points U, V, W, and X.

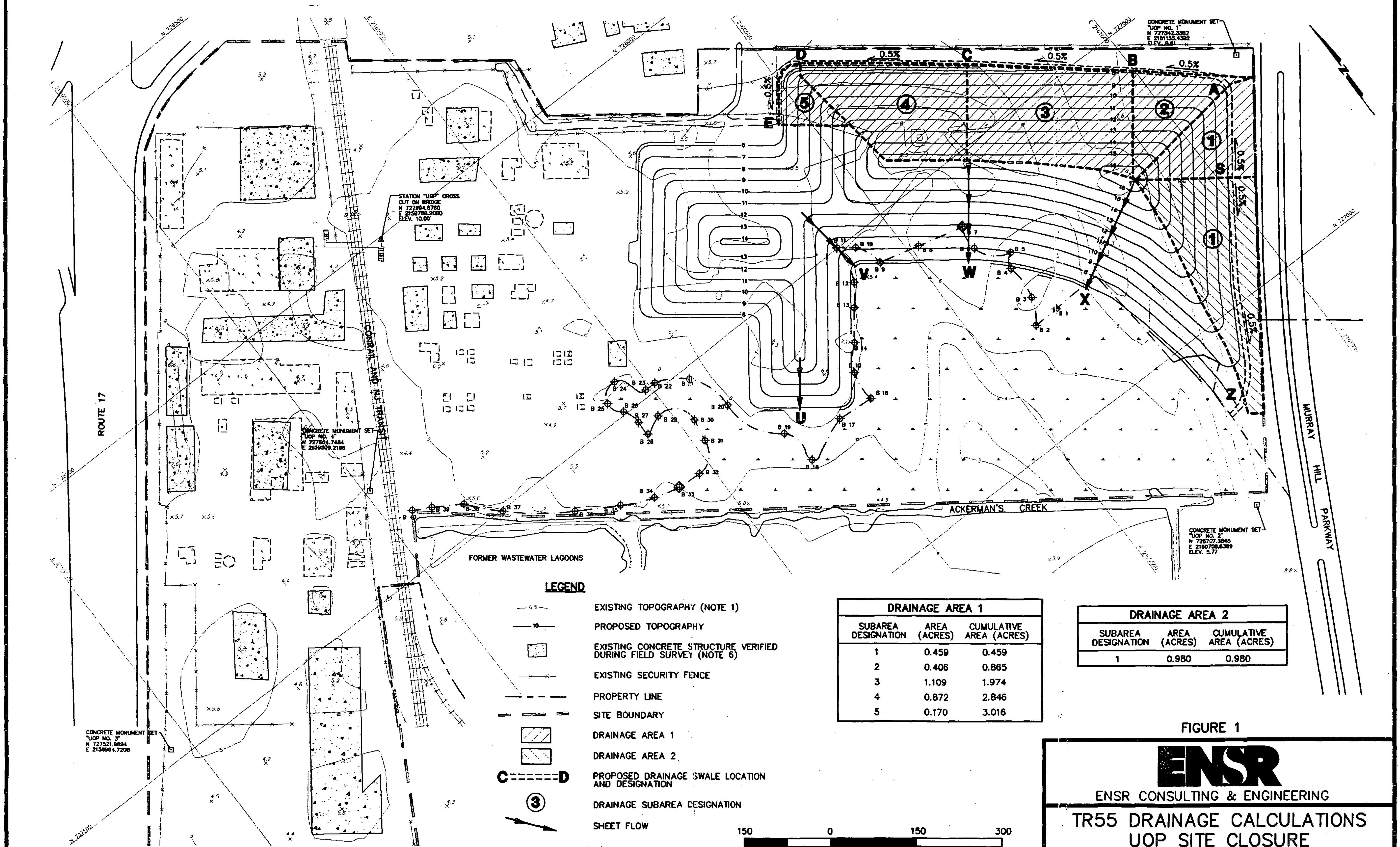
REFERENCES: 1. SCS, TR-55 Methodology
2. Figure 1 (attached)

METHODOLOGY: Use Manning's kinematic solution (Overton and Meadows, 1976) where:

Tt = [0.007(nL)^0.8] / [(P2)^0.5/s^0.4], and

V = L / Tt

Point	Slope s (ft/ft)	Length L (ft)	Manning's n	P2 (inches)	Time T (hour)	Velocity V (ft/sec)
U	0.05	90	0.24	3.5	0.14	0.17
V	0.05	120	0.24	3.5	0.18	0.18
W	0.05	180	0.24	3.5	0.25	0.20
X	0.05	210	0.24	3.5	0.29	0.20



LEGEND

— 5.5 —	EXISTING TOPOGRAPHY (NOTE 1)
— 10 —	PROPOSED TOPOGRAPHY
	EXISTING CONCRETE STRUCTURE VERIFIED DURING FIELD SURVEY (NOTE 6)
	EXISTING SECURITY FENCE
	PROPERTY LINE
	SITE BOUNDARY
	DRAINAGE AREA 1
	DRAINAGE AREA 2
C=====D	PROPOSED DRAINAGE SWALE LOCATION AND DESIGNATION
③	DRAINAGE SUBAREA DESIGNATION
	SHEET FLOW

DRAINAGE AREA 1

SUBAREA DESIGNATION	AREA (ACRES)	CUMULATIVE AREA (ACRES)
1	0.459	0.459
2	0.406	0.865
3	1.109	1.974
4	0.872	2.846
5	0.170	3.016

DRAINAGE AREA 2

SUBAREA DESIGNATION	AREA (ACRES)	CUMULATIVE AREA (ACRES)
1	0.980	0.980

150 0 150 300

SCALE IN FEET
1" = 150'-0"

NOTE: SURVEY INFORMATION IN NGVD OF 1929 OBTAINED FROM ALBERT N. FARALDI GROUP, SECAUCUS, NJ, 1993 AND MARCH 1995, AND NJ STATE PLANE COORDINATE SYSTEM PHOTOGRAPHY, SEPTEMBER 1983. 500-FOOT GRID IN NEW JERSEY STATE PLANE COORDINATE SYSTEM.

FIGURE 1

ENSR

ENSR CONSULTING & ENGINEERING

TR55 DRAINAGE CALCULATIONS UOP SITE CLOSURE EAST RUTHERFORD, NEW JERSEY

DRAWN BY:	DATE:	PROJECT NO.
SSA	4-27-95	0186-002-555

0186A01B

Project: UOP Site Closure
Project Number: 0186-002-555 | Computed by: SSA | Date: 4/21/95
Subject: Drainage Swale Design | Checked by: MSG | Date: 4/28/95

OBJECTIVE: Design drainage swales to control stormwater runoff for the proposed fill area for the UOP site closure.

REFERENCES:

① Standards for Soil Erosion and Sediment Control in New Jersey, April 1987, N.J. State Soil Conservation Committee

② TR-55 Urban Hydrology for Small Watersheds, Ver. 2.00, U.S. Dept. of Agriculture, SCS, June 1986 · printouts

③ Open Channel Flow Module, Ver. 3.42, Haestad Methods, Inc., 1991

④ Open-Channel Hydraulics, Richard H. French, 1985.

METHODOLOGY:

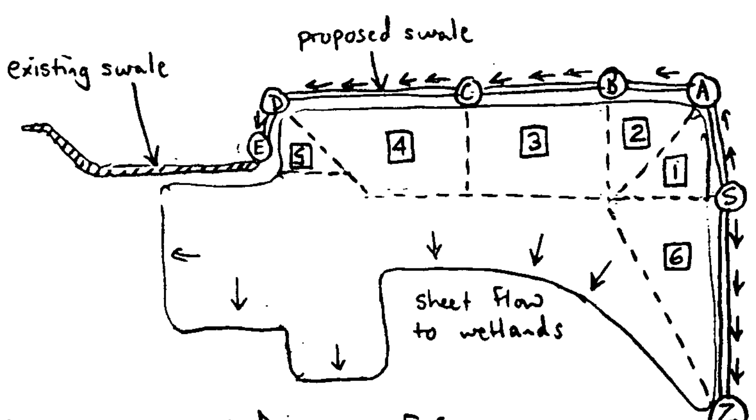
From Reference 1, Section 4.2.1 - 4.3.2:

Design criteria
- Determine capacity using SCS TR-55 (Ref. 2)
- Design for storm frequency - 25 YR. *
- Use a freeboard of 0.5 Ft. *
- Maximum permissable velocity for design flow = 2.5 fps **
- side slopes of channels shall be 3:1 (H:V) Max.
- channels shall be grassed waterways ***

* The site will not be developed during the post-closure period
** Soils in the swales will be silty clay loam, sandy clay loam and will be vegetated
*** Use vegetative retardance factors: D for determination of min capacity and E for determination of max velocity. However, recommended methods based on retardance factors cannot be used because flows are too small.

Design swales:

I. Delineate subbasins and swale locations



Catchment	Area
1	20,000 SF
2	17,700 SF
3	48,300 SF
4	38,000 SF
5	7,400 SF
6	42,800 SF

Refer to attached figure - Figure 1

Project: UOP Site Closure

Project Number: 0186-002-555 Computed by: SSA Date: 4/25/95

Subject: Drainage Swale Design Checked by: Date:

II Calculate peak flow from 25 year storm, SCS TR 55 printout (RF. 2) — see Table 1-1

III Calculate Manning's roughness coefficient n for natural earthen lined swales from Reference 4

SCS method:

- Step 1 - Basic n value for earthen channel = 0.02
- Step 2 - Vegetation - assume turf grass where avg. flow is 1-2 times the height of vegetation - assume ≈ 0.018
- Step 3 - assume swale dimensions with slight variation ≈ 0.000
- Step 4 - obstructions minor ≈ 0.005
- Step 5 - meandering minor - 0.000
- Step 6 - add factors from steps 1-5 = 0.043

$n = 0.043$

IV Size swale using Manning's equation - normal depth, check design with maximum permissible velocity - add freeboard of 0.3 feet Reference 3, - printouts see table 1-2

VI Design outlet control structures
all flow velocities are below 2.5 f/sec
∴ no outlet control structures required

VII Determine flow velocities at points U, V, W, and X to verify that swales will not be required

Sheet flow (depth $d \leq 0.1$ ft)

From Manning's Kinematic solution (Overton and Meadows 1976)

$$T_t \text{ (travel time) hours} = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\, s^{0.4}} = 0.38 \text{ hours}$$

$$V \text{ (velocity)} = \frac{L}{T_t} = 0.22 \text{ ft/sec.}$$

where
$n = 0.24$ from Table 3-1 for dense grass
L = length of slope (300' max)
P_2 = 2yr, 24 hr event = 3.5 inches
s = slope = 0.05 (5% slope)

From attached calculations, all flow velocities are < 2.5 fps ✓

M911013

ENSR

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Conte

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1]The n values are a composite of information compiled by Engman (1986).
[2]Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3]When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

TABLE 4.2 Basic n values suggested by the Soil Conservation Service (Anonymous, 1963b)

Channel character	Basic n
Channels in earth	0.02
Channels cut into rock	0.025
Channels in fine gravel	0.024
Channels in coarse gravel	0.028

TABLE 4.3 Modifying factors for vegetation (Anonymous, 1963b)

Vegetation and flow conditions comparable with:	Degree of effect on n	Range of modifying values
Dense growths of flexible turf grasses or weeds, of which Bermuda grass and blue grass are examples, where the average depth of flow is 2 to 3 times the height of vegetation Supple seedling tree switches such as willow, cottonwood, or salt cedar where the average depth of flow is 3 to 4 times the height of the vegetation	Low	0.005–0.010
Turf grasses where the average depth of flow is 1 to 2 times the height of vegetation Stemmy grasses, weeds, or tree seedlings with moderate cover where the average depth of flow is 2 to 3 times the height of vegetation Brushy growths, moderately dense, similar to willows 1 to 2 years old, dormant season, along side slopes of channel with no significant vegetation along the channel bottom, where the hydraulic radius is greater than 2 ft (0.6 m)	Medium	0.010–0.025

Step 1. *Selection of a Basic n:* In this step, a basic value for a straight, uniform, smooth channel in the native materials is selected. The channel must be visualized without vegetation, obstructions, changes in shape, and changes of alignment. The basic n values suggested by the SCS are summarized in Table 4.2.

Step 2: *Modification for Vegetation:* The retardance due to vegetation is primarily due to the flow of water around stems, trunks, limbs, and branches and only secondarily to the reduction of the flow area. In assessing the effect of vegetation on retardance, consideration must be given to the height of the vegetation in relation to the depth of flow, the capacity of the vegetation to resist bending, the degree to which

Vegetation and flow conditions comparable with:	Degree of effect on n	Range of modifying values
Dormant season, willow or cottonwood trees 8 to 10 years old, intergrown with some weeds and brush, none of the vegetation in foliage, where the hydraulic radius is greater than 2 ft (0.6 m)	High	0.025–0.050
Growing season, bushy willows about 1-year-old intergrown with some weeds in full foliage along side slopes, no significant vegetation along channel bottom, where hydraulic radius is greater than 2 ft (0.6 m)		
Turf grasses where the average depth of flow is less than one-half the height of vegetation		
Growing season, bushy willows about 1 year old, intergrown with weeds in full foliage along side slopes; dense growth of cattails along channel bottom; any value of hydraulic radius up to 10 or 15 ft (3 to 4.6 m)	Very high	0.050–0.100
Growing season, trees intergrown with weeds and brush, all in full foliage; any value of hydraulic radius up to 10 or 15 ft (3 to 4.6 m)		

the flow is obstructed, the transverse and longitudinal distribution of vegetation of various types, the densities and heights of vegetation in the reach being considered, and the critical season; i.e., is the vegetation dormant or growing? The SCS results regarding vegetation are summarized in Table 4.3.

Step 3: *Modification for Channel Irregularity:* In determining the modification required for channel irregularity, both changes in flow area and changes in cross-sectional shape must be considered. The effects of changes in flow area should be examined from the viewpoint of comparing the magnitude of the change with the average area. While large changes in area, if they are gradual and uniform, result in small modifying values, abrupt changes yield large modifying values. In the case of changes of channel shape, the degree to which the change causes the greatest depth of flow to migrate from side to side is critical. Shape changes which yield the largest modifying values are those which shift

TABLE 4.4 Modifying factors for changes in cross-section size and shape (Anonymous, 1963b)

Character of variations in size and shape of cross sections	Modifying value
Changes in size or shape occurring gradually	0.000
Large and small sections alternating occasionally or shape changes causing occasional shifting of main flow from side to side	0.005
Large and small sections alternating frequently or shape changes causing frequent shifting of main flow from side to side	0.010–0.015

TABLE 4.5 Modifying factors for channel surface irregularity (Anonymous, 1963b)

Degree of irregularity	Surfaces comparable with	Modifying value
Smooth	The best obtainable for the materials involved	0.000
Minor	Good dredged channels; slightly eroded or scoured side slopes of canals or drainage channels	0.005
Moderate	Fair to poor dredged channels; moderately sloughed or eroded side slopes of canals or drainage channels	0.010
Severe	Badly sloughed banks of natural channels; badly eroded or sloughed sides of canals or drainage channels; unshaped, jagged, and irregular surfaces of channels excavated in rock	0.020

the main flow from side to side in distances short enough to produce eddies and upstream currents in the shallow area. The SCS recommendations for the modifying values for this effect are summarized in Table 4.4.

The second consideration in this step is the degree of roughness or irregularity of the surface of the channel perimeter. The existing surface should be compared with the surface smoothness which can, under ideal conditions, be obtained with the native materials and with the specified depth of flow. The SCS results for this effect are summarized in Table 4.5.

Step 4: *Modification for Obstruction:* The selection of the modifying value for this factor is based on the number and characteristics of the obstructions. Obstructions considered by the SCS included debris deposits, stumps, exposed roots, boulders, and fallen and lodged logs. In assessing the relative effect of obstructions, one must give consideration to the following: (*a*) the degree to which the obstructions reduce the flow area at various depths of flow, (*b*) the shape of the obstructions (recall that angular objects produce greater turbulence than rounded objects), and (*c*) the position and spacing of the obstructions in both the transverse and longitudinal directions. The SCS recommendations for this modification are summarized in Table 4.6.

Step 5: *Modification for Channel Alignment:* The modifying value for channel alignment is found by adding the modifying values found in steps 2 to 4 to the basic value of n, step 1, to form the subtotal n'. Define ℓ_s = straight length of the reach under consideration and ℓ_m = meander length of the channel in the reach. The modifying value for alignment can then be estimated from Table 4.7 for various values of the ratio ℓ_m/ℓ_s.

Step 6: *Estimate of n:* A value of n can then be estimated by summing the results of steps 1 to 5.

The use of the SCS method in estimating n for a natural channel is best demonstrated by an example.

TABLE 4.6 Modifying factors for obstruction (Anonymous, 1963b)

Relative effect of obstructions	Modifying value
Negligible	0.000
Minor	0.010–0.015
Appreciable	0.020–0.030
Severe	0.040–0.060

TABLE 4.7 Modifying values for channel alignment (Anonymous, 1963b)

ℓ_m/ℓ_s	Degree of meandering	Modifying value
1.0–1.2	Minor	0.00
1.2–1.5	Appreciable	0.15 n'
>1.5	Severe	0.30 n'

RUNOFF CURVE NUMBER COMPUTATION   Version 2.00

Project : UOP SITE CLOSURE   User: SSA   Date: 04-27-95
County : BERGEN   State: NJ   Checked: ____   Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1
Subarea : 1

COVER DESCRIPTION	A	B	C	D
	Hydrologic Soil Group Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Fair condition; grass cover 50% to 75%	-	.459(69)	-	-
Total Area (by Hydrologic Soil Group)		.459		
		====		

SUBAREA: 1   TOTAL DRAINAGE AREA: .459 Acres   WEIGHTED CURVE NUMBER: 69

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1
Subarea : 2

COVER DESCRIPTION	A	B	C	D
	Hydrologic Soil Group Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Fair condition; grass cover 50% to 75%	-	.865(69)	-	-
Total Area (by Hydrologic Soil Group)		.865 ====		

SUBAREA: 2 TOTAL DRAINAGE AREA: .865 Acres WEIGHTED CURVE NUMBER: 69

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1
Subarea : 3

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Fair condition; grass cover 50% to 75%	-	1.97(69)	-	-
Total Area (by Hydrologic Soil Group)		1.97 ====		

SUBAREA: 3 TOTAL DRAINAGE AREA: 1.97 Acres WEIGHTED CURVE NUMBER: 69

RUNOFF CURVE NUMBER COMPUTATION   Version 2.00

Project : UOP SITE CLOSURE   User: SSA   Date: 04-27-95
County : BERGEN   State: NJ   Checked: ____   Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1
Subarea : 4

COVER DESCRIPTION	A	B	C	D
	Hydrologic Soil Group — Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Fair condition; grass cover 50% to 75%	-	2.85(69)	-	-
Total Area (by Hydrologic Soil Group)		2.85		
		====		

SUBAREA: 4   TOTAL DRAINAGE AREA: 2.85 Acres   WEIGHTED CURVE NUMBER: 69

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1
Subarea : 5

COVER DESCRIPTION	A	B	C	D
	Hydrologic Soil Group — Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Fair condition; grass cover 50% to 75%	-	3.02(69)	-	-
Total Area (by Hydrologic Soil Group)		3.02		

SUBAREA: 5 TOTAL DRAINAGE AREA: 3.02 Acres WEIGHTED CURVE NUMBER: 69

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1

Subarea #1 - S-A

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.5	170	0.05	F					0.241
Shallow Concent'd		160	.005	U					0.039

Time of Concentration = 0.28*
=====

Subarea #2 - S-B

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.5	170	0.05	F					0.241
Shallow Concent'd		340	0.005	U					0.083

Time of Concentration = 0.32*
=====

Subarea #3 - S-C

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.5	170	0.05	F					0.241
Shallow Concent'd		610	0.005	U					0.149

Time of Concentration = 0.39*
=====

Subarea #4 - S-D

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.5	170	0.05	F					0.241
Shallow Concent'd		900	0.005	U					0.219

Time of Concentration = 0.46*
=====

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1

Subarea #5 - S-E

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.5	170	0.05	F					0.241
Shallow Concent'd		1020	0.005	U					0.248

Time of Concentration = 0.49*
=====

--- Sheet Flow Surface Codes ---

A Smooth Surface
B Fallow (No Res.)
C Cultivated < 20 % Res.
D Cultivated > 20 % Res.
E Grass-Range, Short
F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense
J Range, Natural

--- Shallow Concentrated ---
--- Surface Codes ---

P Paved
U Unpaved

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1 - SUBAREA S-A

Data: Drainage Area : .459 Acres A_m
Runoff Curve Number : 69 *
Time of Concentration: 0.28 Hours
Rainfall Type : III
Pond and Swamp Area : NONE

Storm Number	1	2	3	4	
Frequency (yrs)	2	10	25	100	
24-Hr Rainfall (in)	3.5	5.0	6.0	7.5	
Ia/P Ratio	0.26	0.18	0.15	0.12	
Runoff (in)	0.95	1.96	2.71	3.93	Q
Unit Peak Discharge (cfs/acre/in)	0.706	0.750	0.768	0.785	q_u
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00	1.00	F_p
Peak Discharge (cfs)	0	1	1	1	

* - Value(s) provided from TR-55 system routines

Calculate peak discharge = $q_p = q_u A_m Q F_p$

$q_p = (0.768 \text{ cfs}/\cancel{\text{acre}}/\cancel{\text{in}})(0.459 \cancel{\text{Acres}})(2.71 \cancel{\text{in}})(1)$

$q_p = 0.96 \text{ cfs}$

GRAPHICAL PEAK DISCHARGE METHOD Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1 - SUBAREA S-B

Data: Drainage Area : .865 Acres A_m
Runoff Curve Number : 69 *
Time of Concentration: 0.32 Hours
Rainfall Type : III
Pond and Swamp Area : NONE

Storm Number	1	2	3	4	
Frequency (yrs)	2	10	25	100	
24-Hr Rainfall (in)	3.5	5.0	6.0	7.5	
Ia/P Ratio	0.26	0.18	0.15	0.12	
Runoff (in)	0.95	1.96	2.71	3.93	Q
Unit Peak Discharge (cfs/acre/in)	0.672	0.716	0.733	0.750	q_u
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00	1.00	F_p
Peak Discharge (cfs)	1	1	2	3	

* - Value(s) provided from TR-55 system routines

Calculate peak discharge : $q_p = q_u A_m Q F_p$

$q_p = (0.733 \text{ cfs/acre/in})(0.865 \text{ acres})(2.71 \text{ in})(1)$

$\underline{q_p = 1.72 \text{ cfs}}$

GRAPHICAL PEAK DISCHARGE METHOD Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1

Data: Drainage Area : 1.97 Acres A_m
Runoff Curve Number : 69 *
Time of Concentration: 0.39 Hours
Rainfall Type : III
Pond and Swamp Area : NONE

Storm Number	1	2	3	4	
Frequency (yrs)	2	10	25	100	
24-Hr Rainfall (in)	3.5	5.0	6.0	7.5	
Ia/P Ratio	0.26	0.18	0.15	0.12	
Runoff (in)	0.95	1.96	2.71	3.93	Q
Unit Peak Discharge (cfs/acre/in)	0.623	0.665	0.681	0.698	q_u
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00	1.00	F_p
Peak Discharge (cfs)	1	3	4	5	

* - Value(s) provided from TR-55 system routines

Calculate peak discharge : $q_p = q_u A_m Q F_p$

$$q_p = (0.681\ \text{cfs/acre/in})(1.97\ \text{acres})(2.71\ \text{in})(1)$$

$$\underline{q_p = 3.64\ \text{cfs}}$$

GRAPHICAL PEAK DISCHARGE METHOD Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1 - SUBAREA S-D

Data: Drainage Area : 2.85 Acres A_m
Runoff Curve Number : 69 *
Time of Concentration: 0.46 Hours
Rainfall Type : III
Pond and Swamp Area : NONE

Storm Number	1	2	3	4	
Frequency (yrs)	2	10	25	100	
24-Hr Rainfall (in)	3.5	5.0	6.0	7.5	
Ia/P Ratio	0.26	0.18	0.15	0.12	
Runoff (in)	0.95	1.96	2.71	3.93	Q
Unit Peak Discharge (cfs/acre/in)	0.582	0.623	0.638	0.654	q_u
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00	1.00	F_p
Peak Discharge (cfs)	2	3	5	7	

* - Value(s) provided from TR-55 system routines

Calculate peak discharge = $q_p = q_u A_m Q F_p$

$q_p = (0.638 \text{ cfs/acre/in})(2.85 \text{ Acres})(2.71 \text{ in})(1)$

$q_p = 4.93 \text{ cfs}$

GRAPHICAL PEAK DISCHARGE METHOD Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: _____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 1 - SUBAREA S-E

Data: Drainage Area : 3.02 Acres A_m
Runoff Curve Number : 69 *
Time of Concentration: 0.49 Hours
Rainfall Type : III
Pond and Swamp Area : NONE

Storm Number	1	2	3	4	
Frequency (yrs)	2	10	25	100	
24-Hr Rainfall (in)	3.5	5.0	6.0	7.5	
Ia/P Ratio	0.26	0.18	0.15	0.12	
Runoff (in)	0.95	1.96	2.71	3.93	Q
Unit Peak Discharge (cfs/acre/in)	0.567	0.606	0.622	0.637	q_u
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00	1.00	F_p
Peak Discharge (cfs)	2	4	5	8	

* - Value(s) provided from TR-55 system routines

Calculate peak discharge : $q_p = q_u A_m Q F_p$

$q_p = (0.622 \text{ cfs}/\cancel{\text{acre}}/\cancel{\text{in}})(3.02 \cancel{\text{acres}})(2.71 \cancel{\text{in}})(1)$

$q_p = 5.09 \text{ cfs}$

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: UOP SITE CLOSURE

Comment: DRAINAGE AREA 1 - SUBAREA S-A

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.043
Channel Slope....	0.0050 ft/ft
Discharge........	0.96 cfs

Computed Results:

Depth............	0.42 ft + 0.3 ft (freeboard) = 0.72 ft
Velocity.........	1.00 fps
Flow Area........	0.96 sf
Flow Top Width...	3.54 ft
Wetted Perimeter.	3.68 ft
Critical Depth...	0.24 ft
Critical Slope...	0.0509 ft/ft
Froude Number....	0.34 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: UOP SITE CLOSURE

Comment: DRAINAGE AREA 1 - SUBAREA S-B

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.043
Channel Slope....	0.0050 ft/ft
Discharge........	1.72 cfs

Computed Results:

Depth............	0.56 ft + 0.3 ft (Freeboard) = 0.86 ft
Velocity.........	1.16 fps
Flow Area........	1.48 sf
Flow Top Width...	4.33 ft
Wetted Perimeter.	4.51 ft
Critical Depth...	0.33 ft
Critical Slope...	0.0469 ft/ft
Froude Number....	0.35 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: UOP SITE CLOSURE

Comment: DRAINAGE AREA 1 - SUBAREA S-C

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.043
Channel Slope....	0.0050 ft/ft
Discharge........	3.64 cfs

Computed Results:

Depth............	0.78 ft + 0.3 ft (freeboard) = 1.08 ft
Velocity.........	1.41 fps
Flow Area........	2.59 sf
Flow Top Width...	5.66 ft
Wetted Perimeter.	5.91 ft
Critical Depth...	0.48 ft
Critical Slope...	0.0424 ft/ft
Froude Number....	0.37 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: UOP SITE CLOSURE

Comment: DRAINAGE AREA 1 - SUBAREA S-D

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.043
Channel Slope....	0.0050 ft/ft
Discharge........	4.93 cfs

Computed Results:

Depth............	0.89 ft + 0.3 ft (freeboard) = 1.19 ft
Velocity.........	1.52 fps
Flow Area........	3.24 sf
Flow Top Width...	6.32 ft
Wetted Perimeter.	6.60 ft
Critical Depth...	0.56 ft
Critical Slope...	0.0407 ft/ft
Froude Number....	0.37 (flow is Subcritical)

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: UOP SITE CLOSURE

Comment: DRAINAGE AREA 1 - SUBAREA S-E

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.043
Channel Slope....	0.0050 ft/ft
Discharge........	5.09 cfs

Computed Results:

Depth............	0.90 ft + 0.3 ft (freeboard) = 1.20 Ft
Velocity.........	1.53 fps
Flow Area........	3.32 sf
Flow Top Width...	6.39 ft
Wetted Perimeter.	6.68 ft
Critical Depth...	0.57 ft
Critical Slope...	0.0405 ft/ft
Froude Number....	0.37 (flow is Subcritical)

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 2
Subarea : 1

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
	Acres (CN)			
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns,parks etc.)				
Fair condition; grass cover 50% to 75%	-	0.98(69)	-	-
Total Area (by Hydrologic Soil Group)		.98		
		====		

SUBAREA: 1 TOTAL DRAINAGE AREA: .98 Acres WEIGHTED CURVE NUMBER: 69

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 2

------------------------------- Subarea #1 - 1 -------------------------------

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.5	170	0.05	f					0.241
Shallow Concent'd		420	0.005	u					0.102

Time of Concentration = 0.34*
=====

--- Sheet Flow Surface Codes ---

A Smooth Surface
B Fallow (No Res.)
C Cultivated < 20 % Res.
D Cultivated > 20 % Res.
E Grass-Range, Short
F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense
J Range, Natural

--- Shallow Concentrated ---
--- Surface Codes ---

P Paved
U Unpaved

GRAPHICAL PEAK DISCHARGE METHOD Version 2.00

Project : UOP SITE CLOSURE User: SSA Date: 04-27-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTH SLOPE DRAINAGE SWALE DESIGN - DRAINAGE AREA 2

Data: Drainage Area : .98 * Acres A_m
Runoff Curve Number : 69 *
Time of Concentration: 0.34 * Hours
Rainfall Type : III
Pond and Swamp Area : NONE

Storm Number	1	2	3	4	
Frequency (yrs)	2	10	25	100	
24-Hr Rainfall (in)	3.5	5.0	6.0	7.5	
Ia/P Ratio	0.26	0.18	0.15	0.12	
Runoff (in)	0.95	1.96	2.71	3.93	Q
Unit Peak Discharge (cfs/acre/in)	0.657	0.700	0.717	0.734	q_u
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00	1.00	F_p
Peak Discharge (cfs)	1	1	2	3	

* - Value(s) provided from TR-55 system routines

Calculate peak discharge = $q_p = q_u A_m Q F_p$

$q_p = (0.717 \text{ cfs/acre/in})(0.98 \text{ acres})(2.71 \text{ in.})(1)$

$q_p = 1.9 \text{ cfs}$

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: UOP SITE CLOSURE

Comment: DRAINAGE AREA 2 - SUBAREA S-Z

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n......	0.043
Channel Slope....	0.0050 ft/ft
Discharge........	1.90 cfs

Computed Results:

Depth............	0.58 ft + 0.3 ft (freeboard) = 0.88 ft
Velocity.........	1.19 fps
Flow Area........	1.59 sf
Flow Top Width...	4.49 ft
Wetted Perimeter.	4.67 ft
Critical Depth...	0.34 ft
Critical Slope...	0.0463 ft/ft
Froude Number....	0.35 (flow is Subcritical)

CALCULATIONS AND COMPUTATIONS

Project: UOP Site Closure

Project Number: 0186-002-555 Computed by: SSA Date: 4/24/95

Subject: Temporary Culvert Design Checked by: MBG Date: 4/28/95

OBJECTIVE: Design temporary reinforced concrete pipe culvert to be installed under the temporary access road / drainage berm.

REFERENCES: ① Standards for Soil Erosion and Sediment Control in New Jersey, April 1987, N.J. State Soil Conservation Committee

② TR-55 Urban Hydrology for Small Watersheds, Ver. 2.00, U.S. Dept of Agriculture, SCS, June 1986 - printouts

METHODOLOGY:

For the worst case scenerio, assume 2.4 Acres of undeveloped exposed soil which will drain to the culvert

Determine Q_{25} (25 YR - 24 HR Storm flow rate)

Given: ① culvert length = 80 LF
② inlet invert = 6.0 FT MSL
③ outlet invert = 5.0 FT MSL

From TR-55 (Ref 2): RCN = 86
Q_{25} = 8 CFS
Q_2 = 4 CFS

Assumptions: ① Mannings n = 0.011 for reinforced concrete pipe - normal
② Pipes have groove end entrance and project from the fill.
∴ Use FHWA Chart No. 1, Scale No. 3
③ Entrance loss coef = 0.20, socket end of pipe projecting from the fill (no headwall)

CONCLUSION: A 2'-Dia Reinforced Concrete Pipe will have a headwater less than 2' to prevent overtopping and will have a flow velocity which will prevent scouring

Culvert will be sloped at 0.5 %

Culvert will have socket end (groove end) entrance at upstream end with pipe projecting from fill.

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ENSR

CALCULATIONS AND COMPUTATIONS

Project: UOP Site Closure

Project Number: 0186-002-555 Computed by: SSA Date: 4/24/95

Subject: Temporary Riprap Apron Design Checked by: MSG Date: 4/28/95

OBJECTIVE: Design outlet protection for the temporary 24"-Dia. reinforced concrete pipe culvert to be installed under the temporary access road / drainage berm.

REFERENCES:

① Standards for Soil Erosion and Sediment Control in New Jersey, April 1987, N.J. State Soil Conservation Committee

② TR-55 Urban Hydrology for Small Watersheds, Ver 2.00, US Dept. of Agriculture, SCS, June 1986 - print-outs

METHODOLOGY:

From the Standards for Soil Erosion and Sediment Control in New Jersey, Section 4.14, Conduit Outlet Protection:

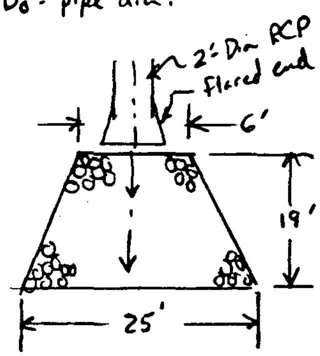
Q_{25} = 8 cfs which is greater than the allowable velocity outlet protection required

For a Horizontal Riprap Apron:

the length : $L_a = \frac{1.8\,Q_{25}}{D_o^{3/2}} + 7\,D_o \quad (TW < \frac{1}{2} D_o)$

$L_a = \frac{(1.8)(8\,cfs)}{(2\,ft)^{3/2}} + 7(2\,ft)$ where D_o = pipe dia.

$\boxed{L_a = 19\ ft}$



the width $= W_e = 3D_o + L_a \quad (TW < \frac{1}{2} D_o)$

$W_e = 3(2) + 19$

$\boxed{W = 25\ ft}$ at end of apron

$W_o = 3D_o$

$\boxed{W_o = 6\ ft}$ at conduit outlet

Riprap size $= D_{50}$ = Median stone diameter

$D_{50} = \frac{0.02}{TW}\left(\frac{Q}{D_o}\right)^{4/3}$ assume $TW = 0.2\,D_o = 0.4'$

$D_{50} = \frac{0.02}{0.4'}\left(\frac{8\,cfs}{2\,ft}\right)^{4/3}$

$D_{50} = 0.3175'$

$\boxed{D_{50} = 4\ inches}$

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ENSR

RUNOFF CURVE NUMBER COMPUTATION Version 2.00

Project : UOP SITE User: JWJ Date: 03-06-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTHEAST CORNER DRAINING TO CULVERT
Subarea : ALL

COVER DESCRIPTION	Hydrologic Soil Group A	B	C	D
		Acres (CN)		
DEVELOPING URBAN AREA (No Vegetation)				
Newly graded area (pervious only)	-	2.4(86)	-	-
Total Area (by Hydrologic Soil Group)		2.4		
		====		

SUBAREA: ALL TOTAL DRAINAGE AREA: 2.4 Acres WEIGHTED CURVE NUMBER: 86*

* - Generated for use by GRAPHIC method

TIME OF CONCENTRATION AND TRAVEL TIME Version 2.00

Project : UOP SITE User: JWJ Date: 03-06-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTHEAST CORNER DRAINING TO CULVERT

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	3.5	300	0.007	B					0.238
Shallow Concent'd		140	0.007	U					0.029

Time of Concentration = 0.27*
=====

--- Sheet Flow Surface Codes ---

A Smooth Surface
B Fallow (No Res.)
C Cultivated < 20 % Res.
D Cultivated > 20 % Res.
E Grass-Range, Short
F Grass, Dense
G Grass, Burmuda
H Woods, Light
I Woods, Dense
J Range, Natural

--- Shallow Concentrated ---
--- Surface Codes ---

P Paved
U Unpaved

* - Generated for use by GRAPHIC method

GRAPHICAL PEAK DISCHARGE METHOD Version 2.00

Project : UOP SITE User: JWJ Date: 03-06-95
County : BERGEN State: NJ Checked: ____ Date: ________
Subtitle: NORTHEAST CORNER DRAINING TO CULVERT

Data: Drainage Area : 2.4 * Acres
Runoff Curve Number : 86 *
Time of Concentration: 0.27 * Hours
Rainfall Type : III
Pond and Swamp Area : NONE

Storm Number	1	2	3
Frequency (yrs)	2	10	25
24-Hr Rainfall (in)	3.5	5	5.5
Ia/P Ratio	0.09	0.07	0.06
Used	0.10	0.10	0.10
Runoff (in)	2.10	3.47	3.94
Unit Peak Discharge (cfs/acre/in)	0.806	0.806	0.806
Pond and Swamp Factor 0.0% Ponds Used	1.00	1.00	1.00
Peak Discharge (cfs)	4	7	8

* - Value(s) provided from TR-55 system routines

PIPE CULVERT ANALYSIS
COMPUTATION OF CULVERT PERFORMANCE CURVE

April 10, 1995
24 inch Concrete Pipe
0.5%

PROGRAM INPUT DATA:

DESCRIPTION	VALUE
Culvert Diameter (feet).................................	2.00
FHWA Chart Number (1,2 or 3)............................	1
Scale Number on Chart (Type of Culvert Entrance)........	3
Manning`s Roughness Coefficient (n-value)...............	0.0110
Entrance Loss Coefficient of Culvert Opening............	0.20
Culvert Length (feet)...................................	80.0
Culvert Slope (feet per foot)...........................	0.0050

PROGRAM RESULTS:

Flow Rate (cfs)	Tailwater Depth (ft)	Headwater (ft) Inlet Control	Headwater (ft) Outlet Control	Normal Depth (ft)	Critical Depth (ft)	Depth at Outlet (ft)	Outlet Velocity (fps)
4.0	0.10	0.97	1.00	0.62	0.70	0.70	4.07
8.0	0.10	1.43	1.30	0.91	1.01	0.91	5.77

Table B-3 Manning's 'n' for Closed Conduits Flowing Partly Full

Type of Channel and Description	Minimum	Normal	Maximum
Brass, smooth:	0.009	0.010	0.013
Steel:			
Lockbar and welded	0.010	0.012	0.014
Riveted and spiral	0.013	0.016	0.017
Cast Iron:			
Coated	0.010	0.013	0.014
Uncoated	0.011	0.014	0.016
Wrought iron:			
Black	0.012	0.014	0.015
Galvanized	0.013	0.016	0.017
Corrugated Metal:			
Subdrain	0.017	0.019	0.021
Storm drain	0.021	0.024	0.030
Lucite:	0.008	0.009	0.010
Glass:	0.009	0.010	0.013
Cement:			
Neat, surface	0.010	0.011	0.013
Mortar	0.011	0.013	0.015
Concrete			
Culvert, straight and free of debris	0.010	0.011	0.013
Culvert with bends, connections, and some debris	0.011	0.013	0.014
Finished	0.011	0.012	0.014
Sewer with manholes, inlet, etc., straight	0.013	0.015	0.017
Unfinished, steel form	0.012	0.013	0.014
Unfinished, smooth wood form	0.012	0.014	0.016
Unfinished, rough wood form	0.015	0.017	0.020
Wood:			
Stave	0.010	0.012	0.014
Laminated, treated	0.015	0.017	0.020
Clay:			
Common drainage tile	0.011	0.013	0.017
Vitrified sewer	0.011	0.014	0.017
Vitrified sewer with manholes, inlet, etc.	0.013	0.015	0.017
Vitrified subdrain with open joint	0.014	0.016	0.018
Brickwork:			
Glazed	0.011	0.013	0.015
Lined with cement mortar	0.012	0.015	0.017
Sanitary sewers coated with sewage slime with bends and connections:	0.012	0.013	0.016
Paved invert, sewer, smooth bottom:	0.016	0.019	0.020
Rubble masonry, cemented:	0.018	0.025	0.030

Source: Table 5-6 of Chow's "Open Channel Hydraulics".

3.2.2.1 Pipe Culvert Diameter

If you are using the Pipe Culvert Analysis program, the program must know the inside diameter of the pipe culvert. The diameter of the culvert opening is important not only in determining the total flow area of the culvert, but also in determining whether the headwater and tailwater elevations are adequate to submerge the inlet or outlet of the culvert.

3.2.2.2 Box Culvert Span (Width of Opening)

Box culverts are essentially rectangular in cross-section. If you are using the Box Culvert Analysis program, you must provide the vertical dimension of the rectangle, measured in feet.

Box culverts are described by the ***span*** and ***rise***, which are the horizontal and vertical dimensions of the culvert opening, respectively. For example, a "4 by 3 box culvert" has a span of 4 feet and a rise of 3 feet.

3.2.2.3 Box Culvert Rise (Height of Opening)

If you are using the Box Culvert Analysis program, the program must also know the culvert rise. The height or rise of the culvert opening is important not only in determining the total flow area of the culvert, but also in determining whether the headwater and tailwater elevations are adequate to submerge the inlet or outlet of the culvert.

Most box culverts have chamfered corners on the inside. The chamfers are ignored by this program in computing the cross-sectional area of the culvert opening. Some manufacturers' literature contains the true cross-sectional area of each size of box culvert, considering the reduction in area caused by the chamfered corners. If you wish to consider the loss in area due to the chamfers, then you should reduce the span of the culvert. You should not reduce the rise of the culvert, because the program uses the culvert rise to determine the submergence of the culvert entrance and outlet.

3.2.2.4 FHWA Chart Number and Scale Number

The Bureau of Public Roads (now called the Federal Highway Administration) published a series of nomographs in 1965 (BPR, 1965), which allowed the inlet control headwater to be computed for different types of culverts operating under a wide range of flow conditions. These nomographs and others constructed using the original methods were republished in 1985 (FHWA, 1985). Appendix C of this manual contains copies of all the pipe culvert and box culvert nomographs from the 1985 FHWA publication.

TABLE 3-1 FHWA Chart and Scale Numbers for Pipe Culverts

Chart No.	Scale No.	Description
1		Concrete Pipe Culvert
	1	Square edge Entrance with headwall
	2	Groove end Entrance with headwall
	3	Groove end Entrance, pipe projecting from fill
2		Corrugated Metal Pipe Culvert
	1	Headwall
	2	Mitered to conform to slope
	3	Pipe projecting from fill
3		Concrete Pipe Culvert: Beveled Ring Entrance
	1(A)	Small bevel
	2(B)	Large bevel

Note: For Chart 3, enter Scale Number 1 for Scale A and Scale Number 2 for Scale B. See Chart 3 in APPENDIX B of this manual for details.

Each of the FHWA charts has from two to four separate scales representing different culvert entrance designs. The appropriate FHWA Chart Number and Scale Number should be chosen according to the type of culvert and culvert entrance. Tables 3-1 and 3-2 should be used as a guideline in selecting the FHWA Chart Number and Scale Number.

TABLE 3-2 FHWA Chart and Scale Numbers for Box Culverts

Chart No.	Scale No.	Description
8		Box Culvert with Flared Wingwalls
	1	Wingwalls flared 30 to 75 degrees
	2	Wingwalls flared 90 or 15 degrees
	3	Wingwalls flared 0 degrees (sides extended straight)
9		Box Culvert with Flared Wingwall and Inlet Top Edge Bevel
	1	Wingwall flared 45 degrees; Inlet top edge bevel = 0.043D
	2	Wingwall flared 18 to 33.7 degrees; Inlet top edge bevel = 0.083D
10		Box Culvert; 90-degree Headwall; Chamfered or Beveled Inlet Edges
	1	Inlet edges chamfered 3/4-inch
	2	Inlet edges beveled 1/2-in/ft at 45 degrees (1:1)
	3	Inlet edges beveled 1-in/ft at 33.7 degrees (1:1.5)
11		Box Culvert; Skewed Headwall; Chamfered or Beveled Inlet Edges
	1	Headwall skewed 45 degrees; Inlet edges chamfered 3/4-inch
	2	Headwall skewed 30 degrees; Inlet edges chamfered 3/4-inch
	3	Headwall skewed 15 degrees; Inlet edges chamfered 3/4-inch
	4	Headwall skewed 10 to 45 degrees; Inlet edges beveled
12		Box Culvert; Non-Offset Flared Wingwalls; 3/4-inch Chamfer at Top of Inlet
	1	Wingwalls flared 45 degrees (1:1); Inlet not skewed
	2	Wingwalls flared 18.4 degrees (3:1); Inlet not skewed
	3	Wingwalls flared 18.4 degrees (3:1); Inlet skewed 30 degrees
13		Box Culvert; Offset Flared Wingwalls; Beveled Edge at Top of Inlet
	1	Wingwalls flared 45 degrees (1:1); Inlet top edge bevel = 0.042D
	2	Wingwalls flared 33.7 degrees (1.5:1); Inlet top edge bevel = 0.083D
	3	Wingwalls flared 18.4 degrees (3:1); Inlet top edge bevel = 0.083D

The programs check the value of the Scale Number to assure that it is available for the given Chart Number. For example, a Scale Number of 4 would be available for Chart 11, but not for Chart 12. Additional information and sketches are included on the FHWA charts in Appendix C.

3.2.2.5 Manning's Roughness Coefficient

This program uses Manning's Equation to compute friction losses in the culvert barrel. The roughness of the culvert is represented by Manning's Roughness Coefficient, commonly called the "n-value". Suggested values for Manning's n-value are listed in Table 5-1 of this manual, and in many hydraulics reference books. Roughness coefficients should be adjusted according to experience in your geographic area, and according to your judgment of the culvert condition.

Some engineers have a tendency to be "conservative" in estimating n-values. However, values which are conservative in one respect may be non-conservative in another. It is not generally acceptable as a designer to simply add a certain percentage to all coefficients in order to produce a conservative design. For example, a culvert which has more flow capacity than the design computations indicate may have excessive flow velocities which cause downstream erosion.

3.2.2.6 Entrance Loss Coefficient

The Entrance Loss Coefficient is used to determine the amount of head loss which occurs at the entrance to the culvert. A higher value for the coefficient gives a higher head loss.

ENTRANCE LOSS COEFFICIENT

The entrance loss coefficient is used to estimate the amount of energy lost as flow enters the culvert from upstream. Entrance losses are computed as a fraction of the "velocity head" or kinetic energy of flow in the culvert. The velocity head in the culvert is computed as:

$$VelocityHead = \frac{V^2}{2g}$$

in which:

V = flow velocity in the culvert (fps)

g = acceleration due to gravity (32.2 feet/second/second)

The velocity head is multiplied by the entrance loss coefficient to estimate the amount of energy loss at the culvert entrance. As shown in the following table, entrance losses can vary from about 0.2 to about 0.5 of the velocity head for box culverts.

The source of the information in the following table is "Street and Highway Drainage", Institute of Transportation and Traffic Engineering, University of California at Berkeley, 1969.

Table B-5 Entrance Loss Coefficient for Box Culverts

Type of Structure and Design of Entrance	Coefficient
Headwall parallel to embankment (no wingwalls):	
Square edge of three edges	0.50
3 edges rounded to radius of 1/12 barrel dimension	0.20
Wingwalls at 15 to 45 degrees to barrel:	
Square-edge top corner	0.40
Top corner rounded to radius of 1/12 barrel dimension	0.20

Table B-6 Entrance Loss Coefficient for Pipe Culverts

Type of Structure and Design of Entrance	Coefficient
Concrete Pipe Projecting from Fill (no headwall):	
Socket end of pipe	0.20
Square cut end of pipe	0.50
Concrete Pipe with Headwall or headwall and wingwalls:	
Socket end of pipe	0.10
Square cut end of pipe	0.50
Rounded entrance, with rounding radius = 1/12 of diameter	0.10
Corrugated Metal Pipe:	
Projecting from fill (no headwall)	0.80
With Headwall or headwall and wingwalls, square edge	0.50